May 4, 1937. J. F. TURNER ET AL 2,079,135

STOKER MOTOR CONTROL

Filed Sept. 6, 1934 4 Sheets-Sheet 1

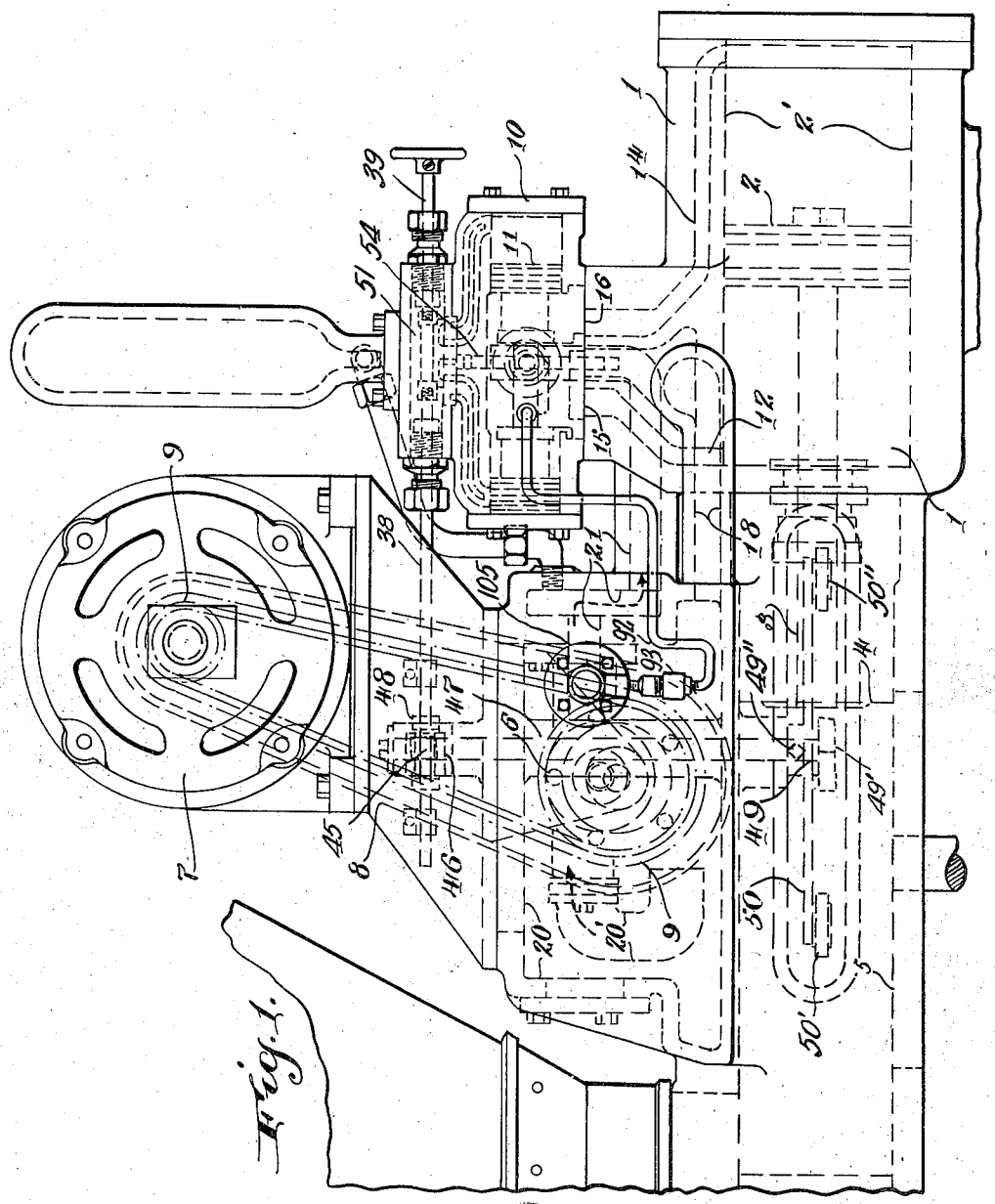


Fig. 1.

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STOKER MOTOR CONTROL

Filed Sept. 6, 1934 4 Sheets-Sheet 2

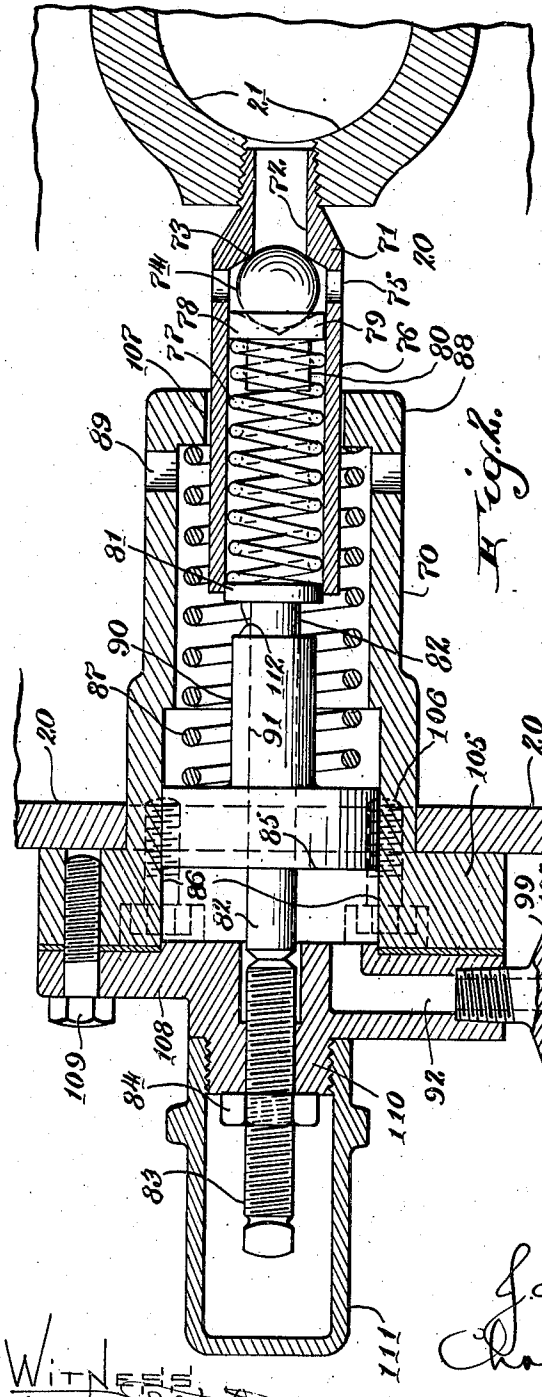


Fig. 2.

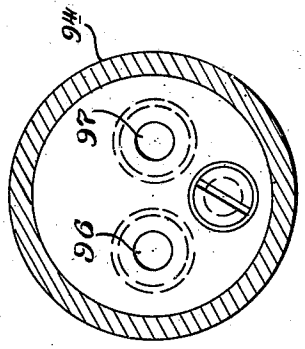


Fig. 3.

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STOKER MOTOR CONTROL

Filed Sept. 6, 1934 4 Sheets-Sheet 3

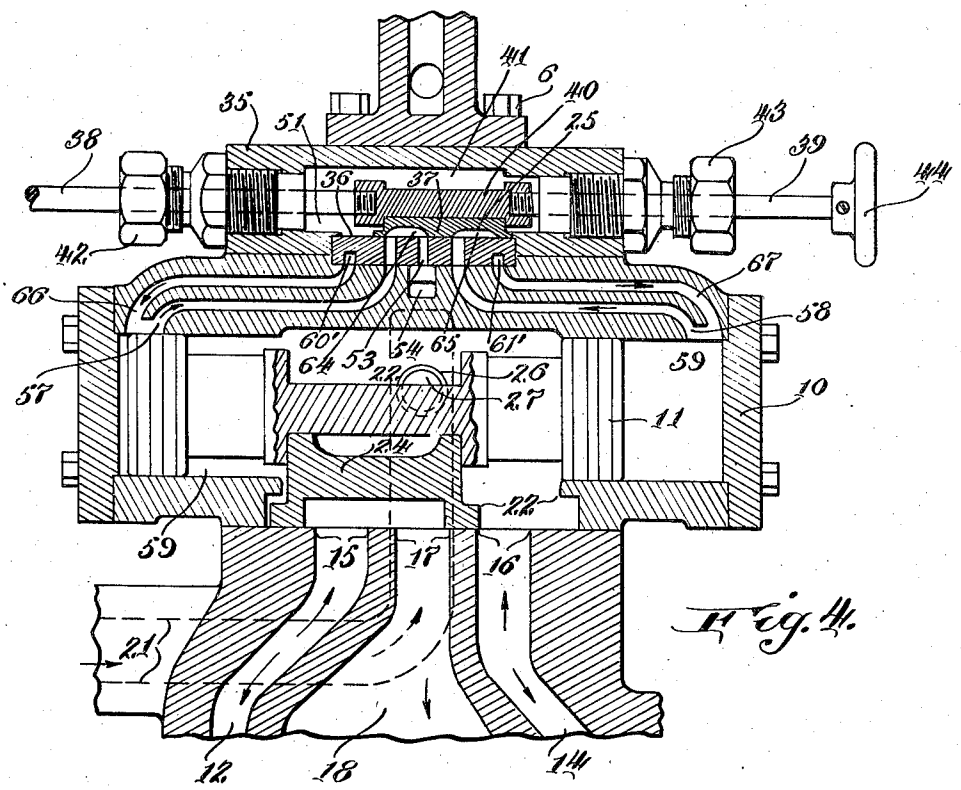


Fig. 4.

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STOKER MOTOR CONTROL

Filed Sept. 6, 1934 4 Sheets-Sheet 4

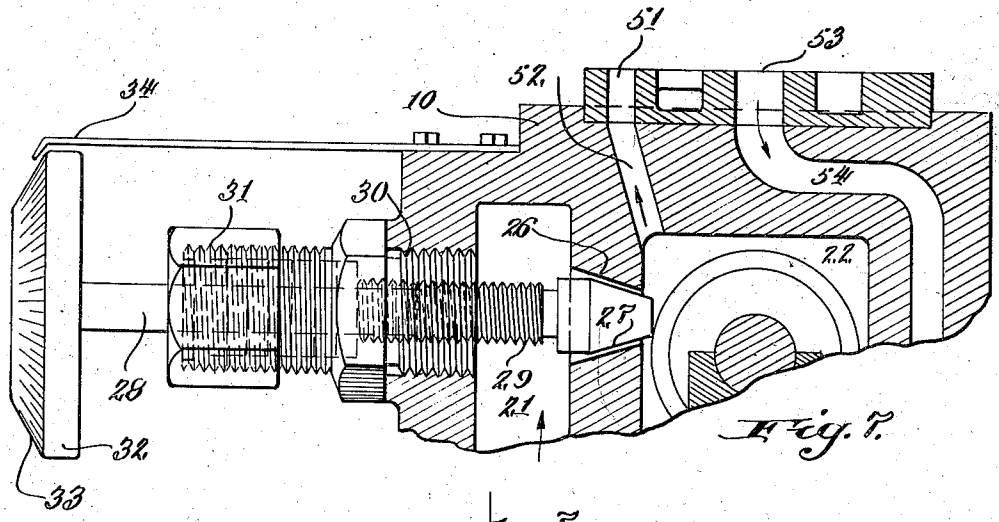


Fig. 7.

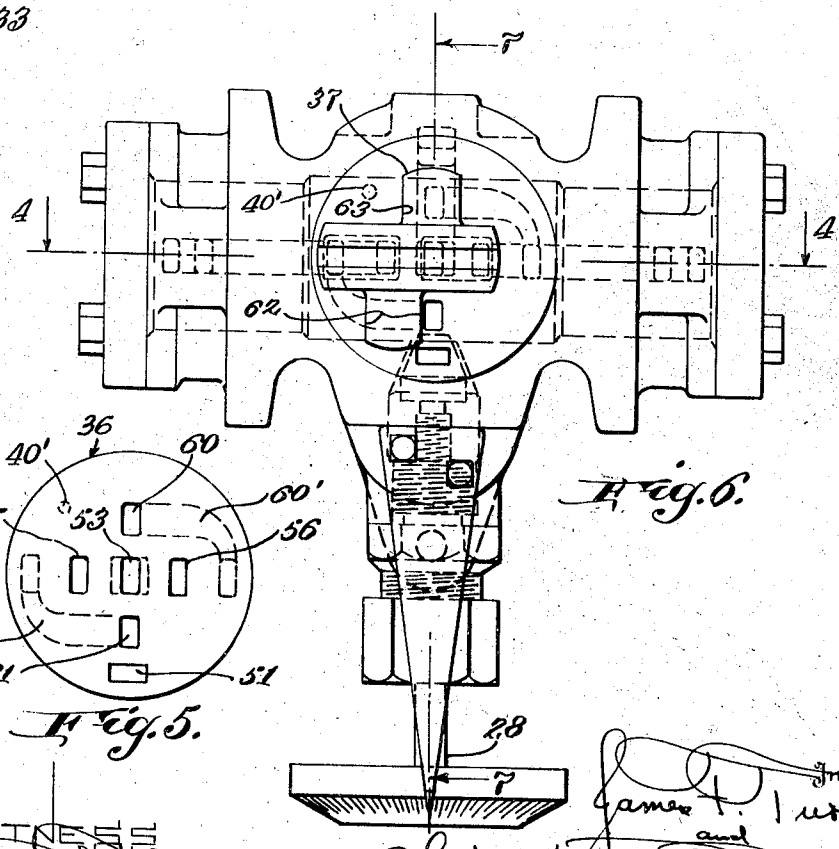


Fig. 6.

Fig. 5.

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UNITED STATES PATENT OFFICE

2,079,135

STOKER MOTOR CONTROL

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Application September 6, 1934, Serial No. 742,973

19 Claims. (Cl. 60—52)

The invention relates to fuel feeding, the invention having been developed in connection with the feeding of fuel to an underfeed stoker. Such stokers are provided with a retort into which the fuel is forced by means of a ram. This retort is in accordance with the established practice associated with inclined grates which slope downwardly from twyer blocks at the top of the retort which is open. The fuel as it is forced into the retort by the ram rises upwardly and flows over the twyer blocks, being heated in the retort and burned as it passes down the incline.

The device of the invention has been most generally applied to small plants though it is capable of use on the larger plants and the device of the invention, though it is particularly adapted for use with underfeed stokers, may be applied to other types of stokers and to fuel feeding in general.

In the operation of underfeed stokers, one of the important difficulties encountered is incident to the cramping and jamming of coal or other fuel in front of the ram, either in the retort where a certain amount of coking takes place in addition to the wedging and jamming of the fuel as it is advanced or in the ram passage where the feeding of the fuel by pressure from the rear also results in wedging and jamming of the particles or lumps of fuel.

While it is possible to provide continuously, sufficient power to overcome any resistance which may be offered, the consumption of power under these circumstances is excessive and the expense too great, particularly in the operation of small plants. Under any circumstances there is an important loss of economy in feeding coked fuel in this way.

When a source of power is employed which is commensurate with the ordinary consumption of power by the motor, the presentation of an excessive resistance to the operation of the ram due to cramping or coking of the fuel not infrequently stops the operation of the motor entirely so that in the absence of close supervision the fuel feed being discontinued, the fire burns low or goes out, the steam pressure is lost and the operation of the plant ceases.

In the plant to which the invention is applied the ram is operated by means of a fluid pressure motor, generally known as a hydraulic motor, the operating pressure being obtained by means of a relatively small pump which to the best advantage is electrically driven, though it may be driven from other sources of power. The system illustrated provides for continuous circulation, i. e., the hydraulic fluid is fed to the motor under pressure by the pump and discharged from the motor into a chamber from which it passes to the intake or suction side of the pump. This arrangement is not, however, essential to the use of the invention in all the forms contemplated.

The object of the invention is to provide for the normal operation of the motor at a relatively low pressure which places a comparatively small burden upon the pump and the source of power as an electric motor from which the pump is driven, the pressure of the fluid being automatically built up by the pump when an obstruction is encountered by the ram, the working pressure of the fluid supplied to the hydraulic motor being automatically increased, the power and piston thrust generated by the hydraulic motor and applied to the same are correspondingly increased until the obstruction or resistance is overcome when the pressure is immediately dropped to normal and operation of the motor and pump at normal pressure continues until other excess resistances whereby the hydraulic motor is overloaded are encountered, when the building up of pressure is repeated.

In accordance with the preferred form of the invention illustrated, this object is attained by bypassing a portion of the hydraulic fluid pumped which is returned to the intake of the pump without entering the hydraulic motor. This prevents the building up of pressure in the motor beyond a predetermined point and hence prevents a consumption of power beyond the predetermined normal until an excess resistance or overload is encountered when the bypass is automatically closed, the pump builds up in the supply of hydraulic fluid to the motor a pressure which increases the power of the motor and the piston thrust applied to the fluid until it overcomes the resistance. This operation is limited by a predetermined maximum pressure generated by the pump which in accordance with the practice of the invention is several times the normal pressure. In this way any resistance which is encountered is easily overcome following which the pressure of the supply of fluid to the motor and the generation of power by the hydraulic motor and the consumption of power by the pump are returned to normal.

In this way the plant has a normal operation with a low consumption of power adapted to fuel feeding under normal conditions and only in relatively rare instances is it necessary to build up

the pressure of the hydraulic motor using an increased consumption of power for a few seconds only until an excessive resistance is overcome. In this way a very considerable economy is effected and, more important than this, an absolutely dependable operation of the fuel feed is attained.

In the accompanying drawings we have illustrated so much of a stoker motor of the hydraulic type, a ram driven thereby, a ram passage, a fuel hopper, a pump and an electric motor for driving the pump to which the device of the invention is applied, as is necessary to a full comprehension of the manner of constructing, operating, applying and using the invention.

In the drawings:

Figure 1 is a side elevation of a hydraulic motor and a ram operated thereby together with a pump for supplying hydraulic fluid under pressure to the motor and an electric motor for driving the pump.

Figure 2 is a section on the axis of the relief valve of the invention, also showing its connection to the pump pressure passage.

Figure 3 is a section on the line 3, 3 in Figure 2.

Figure 4 is a section on the line 4, 4 in Figure 6, through the hydraulic motor valve chamber and the pilot valve chamber including the valve passages leading from the valve casing to and from the motor cylinder.

Figure 5 is a top plan of the pilot valve seat removed.

Figure 6 is a top plan view of the motor valve casing with the pilot valve casing removed showing the pilot valve and seat and also showing the throttle valve.

Figure 7 is a section on the line 7, 7 in Figure 6, showing the throttle valve, the pump passage and the hydraulic motor valve chamber.

Referring to the drawings by numerals, each of which is used to indicate the same or similar parts in the different figures, the construction shown comprises a hydraulic or equivalent motor with its cylinder 2' and piston 2, connected by a piston rod 3 to a fuel feeding ram 4 which operates in a ram passage 5 in alignment with the hydraulic motor cylinder. The construction also includes a hydraulic fluid pump 6, which is driven by means of an electric motor 7 through and by a belt 8 which engages a pulley 9 on the shaft of the electric motor driving a pulley 9' which operates the pump to provide a suitable supply of hydraulic fluid under pressure to the motor.

The hydraulic motor cylinder 1 is connected at each end to a valve casing 10 containing a piston or other suitable valve 11, such connection being shown in the form of intake and exhaust passages 12 and 14. The passages 12 and 14 terminate in the valve casing 10 in intake and exhaust ports 15, 16 and there is an exhaust port 17 which in the form of the invention shown is connected to the exhaust passage 18 leading to the low pressure or suction chamber 20 from which hydraulic fluid is supplied to the pump, which has an intake 20' in chamber 20. The fluid under pressure from the pump 6 is led by way of pressure passage 21 to the pressure chamber 22 of the valve casing 10 to be delivered by way of the ports 15, 16 and the passages 12, 14 to the respective ends of the hydraulic motor cylinder. This distribution of the hydraulic fluid under pressure is performed under the control of the slide valve 24 which in the form of the invention shown is operated by the valve piston 11. This piston 11 in the form shown is a double ended piston operated from both ends by hydraulic fluid in both cylinder ends, being controlled by the pilot valve 25. The pressure chamber 22 is illustrated fragmentarily in section in Figures 4 and 7 in connection with the adjacent end of the pressure passage 21, to which it is connected by a throttle valve seat 26 controlled by a throttle valve 27 shown as operated by a screw stem 28. The valve 27 is secured to the stem 28, the threaded portion 29 of the stem 28 being engaged with a screw plug 30 seated in a suitable opening in the wall of the passage 21, the plug 30 having combined therewith a suitable packing gland 31. The valve stem 28 is shown as provided with a circular graduated head or handle 32 secured to the outer end of the stem 28, the graduations being indicated by reference character 33. These graduations cooperate with a suitable stationary pointer 34 secured to the valve casing 10.

The throttle valve 27 is used to determine by throttling the normal pressure of the motor fluid in the chamber 22. It may be operated and located in any convenient manner, the above details being merely the preferred form.

A similar type of cylinder valve controlling a hydraulic motor is illustrated in our Patent No. 2,004,558 the operation of the cylinder valve being in turn controlled by a pilot valve which is identical with the pilot valve 25 of the present construction. The pilot valve assembly comprises a casing 35 containing a valve seat 36 and a pilot slide valve 37 cooperating with the seat and actuated by means of valve rods projecting at one end of the valve casing at 38 and at the other end of the valve casing at 39, said rods being threaded at their inner ends into the corresponding ends of a valve carrier 40 in the pilot valve chamber 41 of the pilot valve casing 35. The rod 38 projects at one end through a packing gland 42 and the rod 39 projects at one end through a packing gland 43, the rod 39 having secured to its outer end a handle 44 for use in the manual operation of the pilot valve and the manual control of the stoker. The motor 1 is automatically controlled by means of a lever mechanism like that of our copending application No. 649,558, shown in plan in Figure 5 of said application. This mechanism comprises a horizontally arranged lever 50 at the side of the ram and extending in the general direction of the ram 4. This is secured at its center by means of a set screw 49'' to the lower end of an upright shaft 49 which is seated in a boss projecting upwardly from the lever 50. This shaft rotates in suitable bearings 47 in the main casting containing the ram passage, motor cylinder, etc. The shaft 49 carries at its upper end a lever 45 which projects in a horizontal plane at right angles to the lever 50. The lever 45 which oscillates with the shaft has jaws 46 which straddle the rod 38 between the stops or abutments 48 on said rod. Lever 50 carries followers 50', 50'' which are in the path of the cam member 49' which projects from the side of the ram 4. At each end of the ram stroke the contact of the cam member with the followers 50', 50'' at the ends of the lever 50 serves to swing the lever 50, likewise swinging or rocking the lever 45, moving the rod 38 by contact of the jaws 46 with the stops or abutments 48, shifting the valve 37 as in the previous construction described in the copending application. The operation of this construction being a mere incident to the operation of a well known

control valve, is no part of the present invention. The shifting of the valve 37 operates the piston 11, shifting the hydraulic motor valve 24, admitting hydraulic fluid to the corresponding end of the cylinder 2' and effecting a stroke of the motor, when the pilot valve is again operated and another stroke of the motor is effected in due course as above. The power and hence the speed of the motor is controlled as hereinafter described, the mechanism for the purpose being the important subject of the invention.

The piston 11 of the hydraulic motor slide valve 24 which controls the supply of hydraulic fluid under pressure to the hydraulic motor cylinder 2' and the exhaust therefrom is controlled by the pilot slide valve 37 which slides on the pilot valve seat 36 shown in top plan in Figure 5. This seat contains an inlet passage 51 which may be otherwise suitably located. By way of this port fluid under pressure is supplied to the pilot valve chamber 41, the passage 51 being connected to the pressure chamber 22 of the cylinder valve casing by a passage 52. The pilot valve seat 36 is provided with a center exhaust port 53 connected by an exhaust passage 54 to the motor exhaust 18 and with end exhaust ports 55, 56 on each side of the exhaust port 54 in the direction of the valve traverse. These ports 55 and 56 are connected by exhaust passages 57, 58 to the respective head ends of the respective valve cylinders 59. The pin 40' Figures 5 and 6, positions the valve seat 36 relatively to the casing 10, giving the desired registration of the passages in the seat and in the casing. The pilot valve seat is also provided with pressure ports 60, 61, spaced laterally from the center exhaust port 53 to be covered and uncovered by the pilot slide valve 37 best illustrated in plan in Figure 6 and shown in section in Figure 4. These ports 60 and 61 are uncovered alternately and when either port is uncovered the corresponding hydraulic motor valve cylinder 59 is connected to a supply of hydraulic fluid under pressure led to the pilot valve chamber 41 by way of the passages 51 and 52 from the cylinder valve chamber 22. To effect the alternative closing and opening of the pressure ports 60, 61, the pilot slide valve 37 is provided with staggered and lateral extensions 62 and 63, and to provide for the alternate connection of the end exhaust ports 57 and 58, leading from the head ends of valve cylinders 59 to the central exhaust port 53, the slide valve 37 is provided with grooves or passages 64 and 65 in its bottom surfaces. The hydraulic motor valve casing 10 is also provided with inlet or pressure passages 66, 67 connected to the head ends of the respective hydraulic motor valve cylinders 59 and to the pressure ports 60, 61, in the pilot valve seat by passages 60', 61' in said seat continuous with the corresponding inlet or pressure passages 66, 67. As the motor valve 24 is shifted by the operating of the pistons 11 in the cylinders 59 under the control of the pilot valve 37, the ports 15 and 16 are alternately opened to the pressure in chamber 22, and connected to exhaust passage 18 which in the form shown leads to pump suction or supply chamber 20 and may lead to any suitable exhaust.

The relief valve in combination with the motor and a supply of fluid under pressure to operate the same with throttling means between the motor and the source of supply, the manner of connecting the relief valve to the hydraulic fluid pressure line on both sides of the throttling means and the details of the relief valve assembly constitute the novel subject matter of the invention.

The relief valve assembly 70 in the form shown comprises a seat member 71 connected to the pressure passage 21 which receives fluid under pressure directly from the pump. This seat member 71 has a relief passage 72 connected to the passage 21 at the outer end of which passage is a seat 73. Cooperating with this seat in the form of the invention shown is a ball valve 74 for which any suitable type of nonreturn valve may be substituted. At the sides of the valve seat are discharge openings 75 which in the form of the invention shown lead to the low pressure or suction chamber 20 in which the seat member 71 is located. This seat member 71 as illustrated is extended beyond the seat 73 in the form of a tubular spring casing 76 in which is located the relief valve spring 77 which tends to hold the check valve or nonreturn valve ball 74 in contact with the seat 73. This spring engages at one end the disk 79 of valve cap 78 which disk is concaved on one side to fit the ball and provided on the other side with a projecting stud 80 which is enclosed in the end coils of the spring 77. The spring 77 bears at the end opposite to the stud 80 and disk 79 against a plunger 81 which slides in the tubular spring casing 76, thus determining the tension of the spring and the pressure on the ball which tends to maintain it closed against the pressure of the hydraulic fluid in the passage 21. The plunger 81 is carried by a pin 82 which extends to the left in Figure 2 from the plunger 81, being engaged at its extreme end by an adjusting screw 83 which is held in adjusted position by a lock nut 84, the screw 83 being threaded into a suitable tapped hole in head 108, to be described. This head is stationary. Thus, the pressure at which a portion of the hydraulic fluid is discharged through the relief valve seat 73 and/or by-passed around the throttle, is regulated. Under normal load and pressure the valve is open, the spring being adjusted and the excess fluid pumped at this pressure, the amount of which is a function of the resistance offered to the operation of the motor due to the resistance of the ram, and of the power applied to the pump, is discharged and/or by-passed as hereinafter described. By checking the discharge, the pressure of the fluid supplied to the motor is increased and the power of the hydraulic motor 1 correspondingly increased. In this connection it is of interest that the seat 73 is connected to the passage 21 at a point between the pressure side of the pump or other source of hydraulic fluid under pressure and the throttle 27. This throttling member in the normal operation of the pump effects a reduction of the difference in pressure between the pressure passage 21 and the valve chamber 22, from which latter the hydraulic fluid passes to the hydraulic motor, it being further of interest that the adjustability of the throttle opening through the seat 26 is not essential to the functioning of the relief valve in accordance with the invention, but such adjustability is desirable in the operation of the hydraulic motor under any circumstances.

It is the object of the invention, as already pointed out, to cause the hydraulic motor to operate under normal loads with the minimum of power, utilizing a portion of the hydraulic fluid pumped at a low pressure, the remainder of the fluid being discharged from the pressure passage between the pump delivery and the throttle, and preferably bypassed around the throttle

from the pressure to the suction side of the pump. As an excess resistance is encountered at the ram, it is the purpose of the invention to check the discharge of the fluid at the relief valve 80 whereby the pressure in the hydraulic fluid on the pressure side of the pump, i. e., in the passage 21, is built up, communicating the increased pressure through the throttle opening to the chamber 22 on the intake side of the hydraulic motor. To accomplish this result, an increased closing tendency is imparted to the relief valve member 74. This increased closing tendency is effected in accordance with the preferred form of the invention by means of a release valve piston 85 mounted in the release valve cylinder 86, see Figure 2, and fitting said cylinder to slide therein in response to hydraulic pressures set up in the cylinder or other convenient type of expansible chamber similarly connected. Beneath the piston 85 and opposed to the expansion of the space between the piston and head 108, we have shown a coil spring 87 engaging the piston at one end and at the other end engaging the bottom of a cylindrical spring housing 88 which surrounds the spring. This housing 88 projects into the pump intake or suction chamber 20 and is vented into this chamber at 89, the cylinder 86 being formed in the opposite end of the casing 88, and also shown as projecting into chamber 20. The piston 85 as shown slides on the pin 82 as to which it serves as a guide and by which it is partially guided. As shown, the piston is provided with a short tubular shank or piston rod 90 which extends to the right in the direction of the valve 74, provided with an internal slide bearing 91, in which the pin 82 has a sliding fit. The bearing also extends through the piston proper as shown. The pin 82 slides in the piston 85 and bearing 91 and the piston 85 moves on the pin, being also guided and supported in the cylinder.

The casing 88 including the cylinder 86 in the form shown extends through the wall of the chamber 20 and fits therein, being secured to said wall from without by a flange 105 formed on cylinder 86, which flange immediately overlies and fits closely to the wall, being held by screw bolts 106. The spring casing 76 which is shown as integral with the relief valve seat 71, extends into the spring casing 88 through an opening 107 in the end wall of the casing and the adjusting screw 83 is seated in a piston head 108 which closes the end of the release valve cylinder 86, the head where it bears against flange 105 on which it is seated, being suitably packed. It is held by screw bolts 109. The adjusting screw 83 is threaded into a boss 110 formed on the cylinder head 108 and as shown it is protected by a cup 111 threaded on to the outer end of the boss 110.

The release valve cylinder 86 is connected by a passage 92 and 92' to the hydraulic motor valve chamber 22, i. e., between the hydraulic motor intake and throttle valve seat 26, which, as already pointed out, contains the throttled hydraulic fluid under the pressure at which it is presented to the hydraulic motor. Inserted in this passage 92 between the cylinder 86 and chamber 22 is a check valve assembly 93 having a casing 94 which is shown as formed in two parts 94', 94'', having a threaded engagement with each other; between the parts 94' and 94'' is clamped a valve seat 95 having two ports 96, 97 extending therethrough, both connected by said casing as to their opposite openings to the two ends of the passage 92, 92', on the two sides of the valve casing 94. Cooperating with one of these ports is a check valve 97' shown as in the form of a ball valve held normally in contact with its seat by a coil spring 98, the valve being engaged with the side of the seat toward the cylinder 86. The chamber 99 within the casing 94 is divided into two parts by a partition 100, and the half of the chamber on the right side in Figure 2 opposite the side containing valve 97' is closed at its upper end by a ball valve 101 cooperating with a valve seat member or block 102 containing a passage with a valve seat 103 disposed toward the passage 92' adjacent the chamber 22 and held normally in contact with its seat by a coil spring 104. The presence of the valve assembly 93 in the passage 92, 92' is not absolutely essential to the operation of the relief valve or to the control of its operation by the piston 85 in the cylinder 86 but it is of great advantage in preventing frequent operation of the piston to increase the closing tendency of the valve 74 and thus build up the pressure in the passage 21 and the chamber 22 in response to minor changes of load where such increased pressure is not necessary to operate the ram with reasonable uniformity of speed. Frequent operation involves frequent vibrations or reciprocations of the piston 85 and frequent flexing of the springs 87 and 77 which may be broken, and it also results in loss of power. The valve assembly 93 is instrumental, as already suggested, in preventing unnecessary and too frequent operations of the piston 85 with the consequent increased closing tendency of the valve 74 and building up of motor fluid pressure. It will be noted that the piston 85 which is an unbalanced piston receiving fluid pressure on one side only is of considerable area compared to the area of the valve seat 73 and also of the valve seat or port 96. The valve assembly 93 has the effect of protecting the piston 85 from frequent and relatively slight changes of fluid pressure in valve chamber 22 and also serves to release the excess pressure from the cylinder 86 when the excess load on the motor has ceased so that the back pressure on the motor fluid supply drops and the pump pressure is correspondingly reduced, thus permitting opening of the check valve 74 with further reduction of pump pressure as soon as the excess load on the motor is disposed of.

In operation, when pressure in excess of the normal working pressure, is built up in chamber 22 due to increased load on the hydraulic motor and consequently slower operation of the hydraulic motor, this increased pressure is applied to the piston 85 by introduction of hydraulic fluid under pressure through the passage 92 from chamber 22 with or without check valve 93 into the cylinder 86; the piston 85 moves to the right against the tension of the spring 87 which has previously balanced the pressure in the cylinder 86 due to normal pressure in chamber 22, and when the lost motion at 112 has been taken up by compression of the spring 87, providing a time element in which valve 74 remains open as previously, due to the pressure in passage 21 on the pump side of the throttle opening, the relief valve spring 77 is compressed increasing the tension of the spring and the tendency to close the relief valve by advancing the ball valve 74 toward or against the seat 73. This increases the back pressure on the pump throwing an increased load on the electric motor 7 which in response increases the generation of power continuing the

operation of the pump at the increased pressure, thus communicating increased pressure through the throttle 26, 27 to the cylinder valve chamber 22, from which the hydraulic fluid under increased pressure is supplied to the hydraulic motor increasing the power of the motor and the thrust exerted by the piston on the rim until the excess resistance is overcome and the load on the motor reduced.

When a substantially increased load is placed on the hydraulic motor due to cramping of the fuel, or unusual coking or the like or in any way, as already described, causing excess resistance to the reciprocation of the ram and consequent resistance to the advance of the hydraulic motor piston, the pressure in the chamber 22 of the piston valve being built up and increased as described, this pressure is communicated from the hydraulic motor valve chamber 22 through passage 92' to the casing 94 of the check valve assembly and hence through the port 96 to the valve 97 which is held on its seat by the spring 98 and by normal pressure in the chamber 86 communicated through passage 92 to the top of valve 97. The small area of the valve 97 which is exposed at the seat or port 96, so reduces the actual upward thrust applied to the ball by the increased pressure communicated from the chamber 22 that a considerable increase of pressure is balanced by the spring 98 and a consequently considerable increase in pressure is necessary to open the valve 97. This prevents operation of the piston 85 on slight variations of load which occur frequently in the normal operation of the fuel feed and are overcome without the necessity for building up the pressure by closing the relief valve. In this way frequent reciprocations of the piston 85 with a consequent repeated flexing of the springs 87, 77 and a resulting early breaking or deterioration of these springs is prevented. Also, frequent increases of load on the electric motor when such increase is unnecessary are prevented.

On the opening of the valve 97 the increased pressure from the chamber 22 is communicated through passage 92', the seat or port 96 and the passage 92 to the cylinder 86 moving the piston 85 to the right, the transfer of fluid from the chamber 22 to the cylinder 86 continuing with a consequent advance of the piston 85 to the right until the lost motion at 112 is taken up and further continuing until the spring 77 is compressed, placing increased pressure on the valve 74 and either closing it or partially closing it until the pressure in the pump delivery passage 21 is so increased as to communicate through the throttle 26, 27 and to the chamber 22 sufficient increased pressure to build up the power of the hydraulic motor to an extent which will cause it to overcome the increased load generally in the form of an obstacle interposed in the path of the ram, as already described. When this excess resistance load has been overcome, the increased speed of the hydraulic motor causes a reduction of pressure in the chamber 22 and a reduction of pressure on the under side of the valve 97 which permits this valve to close, and the reduction of pressure in chamber 22 and in the passage 92' resulting from the increased speed of the motor causes sufficient drop of pressure in the portion of the passage 92' adjacent the chamber 22 and beneath the valve 101 so that this valve is unseated due to the excess pressure in the cylinder 86 whereby the excess fluid therefrom is permitted to escape past the seat 103 of the valve 101 returning to the chamber 22 of the piston valve, the fluid being expelled from the cylinder 86 by the operation of the spring 87 until the pressure in the cylinder 86 is returned practically to normal and serves to balance the spring 87, the piston 85 being then retired to the position, Figure 2. In this way the excess pressure is removed from the spring 77, the relief valve 74 is opened by the pressure in passage 72 to a position in which the spring 77 balances the pressure against the ball 74 and operation of the hydraulic motor or pump continues at normal pressure and normal power, the excess fluid from the pump being by-passed from the pressure passage 21 connected to the delivery of the pump through the passage 72 and seat 73 to chamber 20 on the suction side of the pump or otherwise disposed of.

In this way the construction described provides for the bypassing of the hydraulic fluid from the delivery or pressure side of the pump, i. e., from the passage 21 between the pump and the throttle opening at 26 to the suction side of the pump, i. e., the chamber 20 or other suitable point of discharge, the relief valve receiving from any suitable source as the spring 77 a normal tendency to close against the pressure of the pump, which tendency is in operation against normal load overcome by the pressure of the pump as just described, permitting the pump and motor to operate normally at a relatively low pressure and low consumption of power, the invention providing means whereby the tendency of the relief valve to close is increased whenever an increased load is communicated to the hydraulic motor by the ram, or otherwise encountered. This increased closing tendency is communicated to the relief valve 74 from a point in the hydraulic fluid pressure supply passage or pressure passage leading from the pressure side of the pump to the intake of the motor, said point being preferably located between the throttle opening 26 or any throttling means and the intake of the motor in the form shown from valve chamber 22, said increase of the closing tendency being further controlled by the check valve 97 or equivalent means, means also being provided shown in the form of valve 101, for thereafter relieving the pressure set up in cylinder 86 or other expanding chamber in increasing the closing tendency applied to the relief valve 74.

Applicants have thus provided means for operating the hydraulic motor which drives the ram under normal conditions at low pressures with a minimum consumption of power automatically increasing the power to overcome any obstacle which may be encountered whenever such obstacles are encountered, also immediately reducing the power generated to normal when such obstacles have been overcome.

We have thus described specifically and in detail a hydraulic motor control for use in connection with a fuel feed ram or the like, embodying the features of our invention in the preferred form, in order that the manner of constructing, applying, operating and using the same may be fully understood, however, the specific terms herein are used descriptively rather than in a limiting sense, the scope of the invention being defined in the claims.

What we claim as new and desire to secure by Letters Patent is:

1. The combination with a hydraulic motor and a fuel feed ram operated by the motor, a

pump with a pressure passage connecting the pump to the hydraulic motor to supply fluid under pressure to the hydraulic motor to operate the motor, a source of power with a driving connection to the pump, of means in the pressure passage intermediate the pump and the motor intake for checking and determining the flow of fluid under pressure from said pump to the motor intake and effecting a drop of pressure in the fluid as fed to the motor intake when operating at normal speed, a relief valve connected to said passage between the pump and said checking means to discharge fluid therefrom, means tending to close said valve which is normally balanced by the fluid pressure holding the valve open to release a portion of the fluid pumped, permitting the pump and motor to operate under normal motor loads at a relatively low pressure, means connected to said motor supply pressure passage between said check and the motor and operated by the fluid pressure at that point for increasing the closing tendency of the release valve under loads in excess of the normal load as when excess resistance is encountered to the operation of the ram, tending to build up the operating pressure of the hydraulic motor.

2. The combination with a hydraulic motor and a fuel feed ram operated by the motor, and a pump with a pressure passage connecting the pump to the hydraulic motor to supply fluid under pressure to the hydraulic motor to operate the motor, a source of power having a driving connection to the pump to operate the pump, the said pressure passage having means therein intermediate the pump and the motor for checking and determining the flow of fluid under pressure to the motor and effecting a drop of pressure beyond the check under normal loads and speeds, of a relief valve connected to said passage between the pump and said check, a spring tending to close said valve which is normally balanced by the fluid pressure holding the valve open to release a portion of the fluid pumped, permitting the pump and motor to operate under normal motor loads at a comparatively low pressure, means operated by the fluid pressure beyond the check for increasing the closing tendency of the release valve when excess resistance is encountered to the operation of the ram, increasing the motor load above normal and tending to decrease the speed of the motor and to build up the pressure beyond the check, said latter means including a cylinder, a piston therein connected to the spring and a fluid passage connecting said cylinder to the pressure passage between the check and the hydraulic motor to supply fluid to the cylinder to compress said spring, increasing the closing tendency of the valve and the pressure of the fluid delivered to the motor.

3. The combination with a hydraulic motor and a fuel feed ram operated by the motor, a pump with a pressure passage connecting the pump to the hydraulic motor to supply fluid under pressure to the hydraulic motor to operate the motor, a source of power with a driving connection to the pump, the said pressure passage having means therein intermediate the pump and the motor for checking and determining the flow of fluid under pressure to the motor and effecting a drop of pressure beyond said checking means under normal loads and speeds, of a relief valve connected to said passage between the pump and said check, means tending to close said valve which is normally balanced by the fluid pressure holding the valve open to release a portion of the fluid pumped, permitting the pump and motor to operate under said normal motor loads and speeds at a comparatively low pressure, means operated by the fluid pressure beyond the check for increasing the closing tendency of the release valve when excess resistance is encountered to the operation of the ram increasing the motor load above normal and building up the pressure beyond the check, said latter means including a cylinder, a piston therein and a fluid passage connecting said cylinder to the pressure passage between the check and the hydraulic motor, a spring applied to the piston oppositely to said pressure, a check valve in said latter passage opening toward the cylinder and a spring tending to maintain the check valve closed to prevent the communication through said passage to the cylinder of slight changes of pump pressure, and means for releasing fluid from said cylinder when the motor load and intake pressure are reduced to normal after such increased load.

4. The combination with a hydraulic motor and a fuel feed ram operated by the motor, a pump with a pressure passage connecting the pump to the hydraulic motor to supply fluid under pressure to the hydraulic motor to operate the motor, a source of power with a driving connection to the pump, the said pressure passage having means therein intermediate the pump and the motor for checking and determining the flow of fluid under pressure to the motor and effecting a drop of pressure beyond said check by means under normal loads and speeds, of a relief valve connected to said passage between the pump and said check, means tending to close said valve which is normally balanced by the fluid pressure holding the valve open to release a portion of the fluid pumped, permitting the pump and motor to operate under said normal motor loads and speeds at a comparatively low pressure, means operated by the fluid pressure beyond the check for increasing the closing tendency of the release valve when excess resistance is encountered to the operation of the ram, increasing the motor load above normal and building up the pressure beyond the check, said latter means including a cylinder, a piston therein and a fluid passage connecting said cylinder to the pressure passage between the check and the hydraulic motor, means tending to move the piston in opposition to the fluid pressure from said fluid passage, a check valve in said latter passage opening toward the cylinder and a spring tending to maintain the check valve closed to prevent the communication through said passage to the cylinder of slight changes of pump pressure, a closed passage connecting the motor discharge to the intake of the pump providing continuous circulation of the hydraulic fluid and the relief valve being connected to discharge into said latter passage, and means for releasing fluid from said cylinder when the motor load and intake pressure are reduced to normal after such increased load.

5. The combination with a hydraulic motor, a fuel feeding ram connected thereto to be operated thereby, the motor having valve means connected to the ram whereby the operation of the motor is controlled by the ram, a pump with a pressure passage connected to the pump discharge and to the intake of the hydraulic motor to supply the fluid under pressure to the intake of the hydraulic motor to operate the motor, power means for driving the pump and throttling means controlling the pressure passage between the pump and

the intake of the hydraulic motor, of a relief valve connected to the pressure passage between the pump and said throttling means, the relief valve being normally open to release a portion of the fluid pumped whereby the pump and motor are normally operated at relatively low pressure, and means connected to the pressure passage between the pump and the hydraulic motor intake tending to close the relief valve as the motor supply pressure at this point is built up due to increased load on the motor incident to increase of resistance to the operation of the ram, and a passage connecting the motor exhaust to the pump intake providing continuous circulation of the hydraulic fluid from the pump to the motor, said relief valve being connected to discharge into said latter passage.

6. The combination with a hydraulic motor, a fuel feeding ram operated thereby, the motor having valve means connected to the ram whereby the operation of the motor is controlled by the ram, of a pump having a pressure passage connecting the pump delivery to the intake of the hydraulic motor leading fluid under pressure to the motor to operate the motor, means for driving the pump, and pressure reducing means in said passage between the pump and the motor of a relief valve connected to the pressure passage between the pump and said pressure reducing means, means tending to close the relief valve against the pressure in said passage, said relief valve being held open by normal pressure to release a portion of the fluid pumped, causing the pump and motor to operate normally at a relatively low pressure, means for increasing the tendency of said means to close the relief valve comprising an expanding chamber having a moving member, said closing means comprising a spring and a lost motion device whereby said moving member is connected to the valve to increase the tendency to close the valve as said chamber expands beyond a predetermined point, a connection from said pressure passage, at a point between the pressure reducing means and the motor intake, to said expanding chamber to communicate the changes of pressure from said point to the expanding chamber whereby the tendency to close the relief valve is increased as the load on the motor is increased beyond a predetermined point incident to increase of resistance to the operation of the ram and means for releasing the pressure from said chamber when the pump intake pressure is reduced to normal.

7. The combination with a hydraulic motor, a fuel feeding ram operated thereby of a pump having a pressure passage connecting the pump delivery to the intake of the hydraulic motor leading fluid under pressure to the motor to operate the motor, means for driving the pump, and pressure reducing means in said passage between the pump and the motor, a relief valve connected to the pressure passage between the pump and said pressure reducing means, a spring tending to close the relief valve against the pressure in said passage, said relief valve being held open by normal pressure to release a portion of the fluid pumped, causing the pump and motor to operate normally at a relatively low pressure, means for increasing the tendency of said spring to close the relief valve comprising an expanding chamber having a moving member, a lost motion device connected to said member, supporting said spring oppositely to the valve to increase the tendency to close the valve as said chamber expands, a spring tending to contract said chamber, a connection from said pressure passage at a point between the pressure reducing means and the motor intake to said expanding chamber to communicate the changes of pressure from said point to the expanding chamber whereby the tendency to close the relief valve is increased as the load on the motor is increased beyond a predetermined point incident to increase of resistance to the operation of the ram, a passage connecting the motor exhaust to the pump intake providing continuous circulation of the hydraulic fluid, the relief valve being connected to discharge into said latter passage.

8. The combination with a hydraulic motor of a fuel feeding ram operated thereby, a pump having a pressure passage connecting the pump delivery to the intake of the hydraulic motor leading fluid under pressure to the motor to operate the motor, means for driving the pump, and pressure reducing means in said passage between the pump and the motor, of a relief valve connected to the pressure passage between the pump and said pressure reducing means, resilient means tending to close the relief valve against the pressure in said passage, said resilient means being balanced and the relief valve being held open by normal pressure to release a portion of the fluid pumped, causing the pump and motor to operate normally at relatively low pressure, means for increasing the tendency of said resilient means to close the relief valve comprising an expanding chamber having a resiliently controlled moving wall member, a lost motion device for transmitting pressure from said member to said relief valve by way of said resilient means in the direction of closing after a predetermined motion of said wall member, a connection from said passage at a point between the pressure reducing means and the motor intake to said expanding chamber to communicate the changes of pressure from said point to the expanding chamber whereby the tendency to close the relief valve is increased as the load on the motor incident to increase of resistance to the operation of the ram is encountered, and means in said connection for checking communication of slight changes of pressure from said pressure passage to said expanding chamber.

9. The combination with a hydraulic motor, a fuel feeding ram operated thereby, a pump having a pressure passage connecting the pump delivery to the intake of the hydraulic motor leading fluid under pressure to the motor to operate the motor, means for driving the pump, and pressure reducing means in said passage between the pump and the motor, of a relief valve connected to the pressure passage between the pump and said pressure reducing means, resilient means tending to close the relief valve against the pressure in said passage, said resilient means being balanced and the relief valve being held open by normal pressure to release a portion of the fluid pumped, causing the pump and motor to operate normally at relatively low pressure, means for increasing the tendency of said resilient means to close the relief valve comprising an expanding chamber having a moving wall member for transmitting increased pressure through said resilient means to said relief valve in the direction of closing, a connection from said passage at a point between the pressure reducing means and the motor intake to said expanding chamber to communicate the changes of pressure from said point to the expanding chamber whereby the tendency to close the relief valve is increased as the load on the motor incident to increase of resistance

to the operation of the ram is encountered, means tending to contract said chamber, a valve in said connection for checking communication of slight changes of pressure from said pressure passage to said expanding chamber, and a bypass with valve means therein providing for release of fluid from said chamber at a predetermined drop of the pump intake pressure, a passage connecting the motor exhaust to the intake of the pump providing continuous circulation of the hydraulic fluid, said relief valve being connected to discharge into said passage.

10. The combination with a hydraulic motor, a fuel feeding ram operated thereby, a pump having a pressure passage connecting the pump delivery to the intake of the hydraulic motor, leading fluid under pressure to the motor to operate the motor, and means for driving the pump, of flow retarding pressure reducing means in said passage between the pump and the motor, a relief valve discharging from the pressure passage between the pump and said pressure reducing means, means for closing the relief valve comprising an expanding chamber having a moving wall member and resilient means for transmitting pressure from said member to said valve tending to close the same, a connection from said motor pressure passage to said expanding chamber to communicate the changes of pressure from said motor to the expanding chamber whereby the relief valve is closed as an increased load on the motor incident to increase of resistance to the operation of the ram is encountered.

11. The combination with a hydraulic motor adapted to be directly connected to a fuel feeding ram to operate the same, to pump supplying hydraulic fluid under pressure to the motor, power means for operating the pump, said connection being in the form of a pressure passage connected to the delivery side of the pump and to the intake side of the motor, throttling means in said passage for checking the flow of hydraulic fluid effecting a drop of pressure between the pump delivery and the motor intake at normal motor speeds and loads, and a passage connecting the motor exhaust to the intake of the pump, said passage comprising a suction chamber of a relief valve seat connected to said pressure passage between the throttling means and the pump and having a discharge opening into said chamber, a valve co-operating with said seat and closing against the pressure in the pressure passage, a spring tending to close the valve, the valve being balanced by normal pressure in the pressure passage so that the valve is normally open to bypass a portion of the fluid pumped from the pressure passage to said chamber, a cylinder, a spring guide in alignment with said cylinder and forming an extension of said cylinder and also having its axis in alignment with the axis of the valve seat and having a spring support at the end remote from the cylinder, a piston in said cylinder, a spring bearing at one end against said piston and at the other end against said spring support, the end of the cylinder toward the valve seat being vented into said chamber, the spring tending to balance the piston at normal pressure, a plunger mounted to slide in alignment with the cylinder axis and bearing on the valve spring oppositely to the valve, means for applying the thrust of the piston to said plunger to increase the spring pressure tending to close the valve, the advance of the piston in response to the introduction of pressure into the cylinder applying increased pressure to the valve spring and increasing the closing tendency of the relief valve, and a passage connected to the cylinder on the side of the piston remote from said valve and to the pressure passage between the throttling means and the motor intake.

12. The combination with a hydraulic motor adapted to be directly connected to a fuel feeding ram to operate the same, a pump supplying hydraulic fluid under pressure to the motor, power means for operating the pump, a pressure passage connected to the delivery side of the pump and to the intake side of the motor, throttling means in said passage for checking the flow of hydraulic fluid effecting a drop of pressure between the pump delivery and the motor intake at normal motor speeds and loads and a passage connecting the motor exhaust to the intake of the pump, said passage comprising a suction chamber, a relief valve seat connected to said pressure passage between the throttling means and the pump and having a discharge opening into said chamber, a valve cooperating with said seat and closing against the pressure in the pressure passage, a spring tending to close the valve balanced by normal pressure in the pressure passage so that the valve is normally open to bypass a portion of the fluid pumped from the pressure passage to said chamber, a cylinder, a spring guide in alignment with said cylinder, forming an extension of said cylinder in the direction of the valve seat and also having its axis in alignment with the axis of the valve seat and having a spring support at the end remote from the cylinder, a piston in said cylinder, a spring bearing at one end against said piston and at the other end against said spring support, the cylinder being vented into said chamber, a plunger mounted to slide in alignment with the cylinder axis and bearing on the valve spring oppositely to the valve, means for applying the thrust of the piston to said plunger to increase the spring pressure tending to close the valve, the advance of the piston in response to the introduction of pressure into the cylinder applying increased pressure to the valve spring and increasing the closing tendency of the relief valve, said means having a clearance providing lost motion between the piston and the plunger before the pressure of the piston is applied to the plunger as the piston advanced, a passage connected to the cylinder on the side of the piston remote from said valve and to the pressure passage between the throttling means and the motor intake.

13. The combination with a hydraulic motor adapted to be directly connected to a fuel feeding ram to operate the same, a pump supplying hydraulic fluid under pressure to the motor, power means for operating the pump, a pressure passage connected to the delivery, side of the pump and to the intake side of the motor, throttle means in said passage for checking the flow of hydraulic fluid effecting a drop of pressure between the pump delivery and the motor intake at normal motor speeds and loads and a passage connecting the motor exhaust to the intake of the pump, said passage comprising a suction chamber, a relief valve seat connected to said pressure passage between the throttling means and the pump and having a discharge opening into said chamber, a valve cooperating with said seat and closing against the pressure in the pressure passage, a spring tending to close the valve, said spring being balanced by normal pressure in the pressure passage, so that the valve is nor-

mally open to bypass a portion of the fluid pumped from the pressure passage to said chamber, a cylinder, a spring guide in alignment with said cylinder and forming an extension of said cylinder and also having its axis in alignment with the axis of the valve seat and having a spring support at the end remote from the cylinder, a piston in said cylinder, a spring bearing at one end against said piston and at the other end against said spring support, the cylinder being vented into said chamber, a plunger mounted to slide in the direction of the cylinder axis and bearing on the valve spring oppositely to the valve, means for applying the thrust of the piston to said plunger to increase the spring pressure tending to close the valve, the advance of the piston in response to the introduction of pressure into the cylinder applying increased pressure to the valve spring and increasing the closing tendency of the relief valve, said means having a clearance providing lost motion between the piston and the plunger with an interval after the initial motion of the piston and before the pressure of the piston is applied to the plunger, a passage connected to the cylinder on the side of the piston remote from said valve and to the pressure passage between the throttling means and the motor intake, a check valve in said passage opening toward the cylinder and means tending to maintain said valve closed whereby slight variations of pressure at the motor intake are overcome, without transmitting any additional fluid from the cylinder thus checking the tendency to frequent vibrations of the piston in response to minor changes of load but opening to communicate to the cylinder important changes of pressure at the motor intake which must be overcome by increased pressure in the hydraulic fluid and increased power and means for releasing fluid from the cylinder when increases of load have been overcome and the load and fluid pressure at the motor intake are reduced.

14. The combination with a hydraulic motor adapted for direct connection to a fuel feeding ram to operate the ram, a pump, a pressure passage connecting the pump delivery to the intake of the motor, power means for operating the pump, pressure reducing means in the pressure passage between the pump and the motor, a passage connecting the motor exhaust to the pump intact, said passage comprising a chamber of a relief valve seat connected to the pressure passage between the pump discharge and the motor, said valve seat having a discharge opening into said chamber, a valve cooperating with said seat closing against the pressure in said pressure passage, a spring tending to hold the valve closed, a guide for the spring connected to the valve seat, a cylinder, a spring support connected to said cylinder and located in the said chamber, said support having an opening in which the spring guide is located, a piston in said cylinder, the spring guide being in alignment with the axis of the cylinder, a coil spring bearing at one end on the spring support and at the other end against the piston on the side toward the relief valve, a plunger engaging the valve spring oppositely to the valve, means for communicating the motion of the piston to the plunger, a passage connecting the cylinder on the side of the piston opposite to the valve to the pressure passage between the throttling means and the motor intake, means for adjusting the position of the plunger and the tension of the valve spring, the connecting passage to the cylinder having a check valve therein which closes against the pressure from said pressure passage, a spring tending to close said valve and a bypass around said valve, a valve in said bypass opening against the pressure in the pressure passage, and means tending to maintain said latter valve on its seat, the first mentioned valve in said connecting passage serving to prevent the transmission to the cylinder of small fluctuations of load and pressure, but serving to open in response to larger fluctuations, the valve in the bypass being held closed by the increased pressure from the pressure passage, but being opened after each increased load has been overcome to release the excess pressure in the said cylinder and permit the cylinder to be returned to its normal position by the operation of the spring which bears on the piston.

15. The combination with a hydraulic motor and a pump for supplying fluid to the same to operate the motor, of a low pressure fluid supply chamber for the pump to which the motor discharge is connected, a pressure passage connected to the pump delivery and to the motor to operate the same, a throttle in said passage, a relief valve located in the supply chamber and connected to said pressure passage between the pump and the throttle to discharge from said passage into the supply chamber, a spring tending to close said valve, a cylinder in substantial alignment with said valve and spring, a piston in said cylinder having means for applying pressure to said spring to increase the closing tendency of said valve, a second spring bearing on said piston in opposition to the pressure thus applied to the valve and a passage connected to said cylinder and to said pressure passage between the throttle and the motor intake for increasing the pressure on the valve spring as the pressure of the fluid supply to the motor is increased to a point where it moves the piston in opposition to said second spring.

16. The combination with a hydraulic motor and a pump for supplying fluid to the same to operate the motor, of a low pressure fluid supply chamber for the pump to which the motor discharge is connected, a pressure passage connected to the pump delivery and to the motor to operate the same, a throttle in said passage, a relief valve connected to the supply chamber and connected to said pressure passage between the pump and the throttle to discharge from said passage into the supply chamber, a spring tending to close said valve, a cylinder in substantial alignment with said valve and spring, a piston in said cylinder and a lost motion device connecting the piston to the spring for applying pressure to said spring to increase the closing tendency of said valve, a second spring bearing on said piston in opposition to the pressure thus applied to the valve and a passage connected to said cylinder and to said pressure passage between the throttle and the motor intake for increasing the pressure on the valve spring as the pressure of the fluid supply to the motor is increased to a point where it moves the piston in opposition to said second spring, said latter passage having a bypass and two oppositely operating flow check means in parallel in said passage and bypass respectively to limit the operation of the piston to predetermined high and low pressures.

17. The combination with a hydraulic motor and a pump for supplying fluid to the same to

operate the motor, of a low pressure fluid supply chamber for the pump to which the motor discharge is connected, a pressure passage connected to the pump delivery and to the motor to operate the same, a throttle in said passage, a relief valve located in the supply chamber and connected to said pressure passage between the pump and the throttle to discharge from said passage into the supply chamber, a spring tending to close said valve, a cylinder in substantial alignment with said valve and spring, a piston in said cylinder and means connecting the piston to the spring for applying pressure to said spring to increase the closing tendency of said valve, a second spring bearing on said piston in opposition to the pressure thus applied to the valve and a passage connected to said cylinder and to said pressure passage between the throttle and the motor intake for increasing the pressure on the valve spring as the pressure of the fluid supply to the motor is increased to a point where it moves the piston in opposition to said second spring, and means externally located as to said supply chamber for adjusting the tension of the valve spring, said means extending through said piston.

18. The combination with a hydraulic motor and a fuel feed ram operated by the motor of a supply of fluid under pressure and a passage connecting said supply to the hydraulic motor intake to supply fluid under pressure thereto to operate the motor, means in said pressure passage adjacent the motor intake for checking and determining the flow of fluid under pressure from said supply to the motor intake, effecting a drop of pressure in the fluid as fed to the motor when operating at normal speed, a relief valve connected to said passage between the pump and said check, means tending to close said valve, which is normally balanced by the fluid supply pressure holding the valve open to release a portion of the fluid, permitting the motor to operate under normal loads at a relatively low pressure, means connected to said motor supply pressure between said check and the motor intake and operated by the fluid pressure at that point for increasing the closing tendency of the relief valve under loads in excess of the normal load as when excess resistance is encountered to the operation of the ram, thereby tending to build up the operating pressure of the hydraulic motor.

19. The combination with a hydraulic cylinder of a fuel feeding ram operated thereby, a pump having a pressure passage connecting the delivery of the pump to the hydraulic cylinder intake and an electric motor driving the pump, of flow retarding pressure reducing means in said passage between the motor and the pump, a normally open relief valve discharging from said passage between the pump delivery and the pressure reducing means, a hydraulic chamber having a moving wall member, a passage connecting said chamber to the pressure passage beyond said reducing means, resilient means tending to close said relief valve, said resilient means being connected oppositely to said valve and to said moving wall member whereby the tendency to close said valve is increased as the load on the hydraulic cylinder and hence the pressure in said chamber is increased.

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